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BULLETINS AND PAPERS

RELATING TO THE

INCANDESCENT GAS LIGHTING INDUSTRY

HIGH EFFICIENCY ILLUMINANTS

BY H. M. DAGGETT, JR.

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HIGH EFFICIENCY ILLUMINANTS

EVERY new electric or gas illuminating device causes some fear among members of the opposite fraternity that their business will in some way suffer from the use of the more efficient light. These feelings are generally as unwarranted as were those of the gas or electric man who formerly feared his income would be reduced on account of the advent of more efficient lamps giving as much light as the old at greatly reduced cost to his consumers. Improvements generally work out to the ultimate advantage of all. In the case of new gas lamps and new electric lamps, each helps the other to still further become perfected, increasing their value to the consumer, and resulting in larger consumption and greater revenue for the lighting companies.

Let us study some of the features of the most efficient gas and the most efficient electric lamps and their cost of operation. Particular types chosen for comparison are the Tungsten and Tantalum electric, the Inverted Burner and Gas Arc lamps.

TUNGSTEN LAMP.

THE METAL TUNGSTEN. (1) Metallic tungsten is principally obtained from the ores wolframite and scheelite, mined in this country in Colorado, California, and Arizona, and in the foreign countries of Norway, Spain, Queensland, and New South Wales. Prices ranged during the year 1906 from $5.00 to $9.00 per unit for the contained tungsten tri-oxide.

The manufacture of pure tungsten is a difficult matter, owing to its affinity for carbon, oxygen, and other impurities which greatly lower its melting point. In a general way, it may be said that the common practice is to fuse wolframite, if that ore be used, with sodium carbonate, reducing the tungsten to a sodium tungstate. This is then treated with a strong mineral acid, forming tungstic oxide (WO_3), a yellow powder. If scheelite is used, it may be treated directly with a mineral acid and the tungstic oxide obtained. The tungstic oxide is mixed with carbon in some form and strongly heated in crucibles, and the

tungsten is obtained as a metallic powder, which contains more or less carbon.

One method of manufacturing filaments from tungsten powder is to amalgamate it with cadmium and mercury. This amalgam is squeezed through a die into filaments, which are heated by an electric current in vacuo. The cadmium and mercury are expelled, leaving the reduced filament, metallic tungsten.

While the principal use of tungsten is in the manufacture of electric lamps, the sodium tungstate is used in large quantities for fireproofing cloth for curtains, etc., and as a mordant in dyeing. Other tungsten salts, on account of their high specific gravity, are used in weighting silks. Tungsten steel alloys are used for high-speed cutting tools, armor plates, guns, etc.

The melting point of tungsten is the highest of any of the metals used for making incandescent electric lamps, being above 3,000° C., and on this account it is possible to operate it at a higher temperature and consequent greater efficiency. Its resistance increases with increased temperature, while the resistance of carbon lessens with high temperature. This results in the tungsten filament being less affected by voltage changes than the carbon filament, thereby lessening the effect of one factor which influences the life of electric incandescent lamps. One great advantage of the tungsten filament over the carbon filament is that the former, if properly made, does not blacken the globe with use, while carbon, especially if the voltage is a little too high, soon blackens its globe so that a large amount of light is lost.

The tungsten filament has a low resistance, thus making a great length necessary when operated on circuits of 110 volts.

GENERAL DESCRIPTION OF TUNGSTEN LAMP. Referring to Fig. 1, note the similar appearance of this lamp to the familiar 16-c. p. carbon filament electric. The filament, however,

Fig. 1.
TUNGSTEN ELECTRIC.

Fig. 2.
TANTALUM ELECTRIC

is made from metallic tungsten, the properties of which have given us the most efficient commercial incandescent electric lamp. One of the best characteristics of tungsten which has helped to popularize the lamp is the quality of light, which is much whiter than the older types.

The lighting element is composed of a number of hairpin filaments, connected in series and anchored by small wires, to prevent sagging when operated in inclined positions. This arrangement is necessitated by the length of filament required to obtain the necessary resistance. It is recommended, however, by the manufacturers to use these lamps in a vertical position (2) and not to install with key or pull sockets, as serious breakage might result from the vibration when turning on or off the light. The tungsten filament is very brittle, and the mechanical breakage is a serious problem to be overcome. To lessen this, some manufacturers pack each lamp in a special carton (3) and some provide barrels with buffers at top and bottom. (4) Tungsten lamps operate equally well on direct or alternating current.

CANDLE-POWER OF TUNGSTEN LAMPS. Tungsten lamps can be obtained in three sizes—32 c. p., 40 watts; 48 c. p., 60 watts; 80 c. p., 100 watts, the rated efficiency being 1¼ watts per candle. Burning at this efficiency, the average life is claimed to be 800 hours, in which time the initial candle-power will have dropped less than 20 per cent. (4).

The nominal candle-power rating is measured from the horizontal (the point at which the maximum light is obtained). The downward light being very small (5.6 candles for the 60-watt lamp) (3), the use of reflecting glassware is required in practically all cases. A great deal of work will undoubtedly be done toward improving the natural downward distribution of light, as all reflection is made with a loss, and therefore the less required the greater the commercial efficiency.

Figs. 3—3a and 4—4a illustrate the Tungsten lamp with two styles of Holophane reflectors, and their polar curves show the distribution of light with these reflectors. For any particular requirements, reflecting glassware may be obtained to make the curves of most any required form. For window lighting, with units placed close together, the concentrating reflector is used, while for general illumination the distributing type is used.

THE METAL TANTALUM. The metal tantalum was discovered by a Swede named Ekeberge, who gave it its name on account of the tantalizing difficulties that he encountered while investigating it. (5)

Tantalum, during the year 1906, was chiefly obtained from the Black Hills of South Dakota, and from Western Australia, occurring largely as tantalite, stibiotantalite and fergusonite. Prices have ranged from 25 cents to $2.40 per pound. Its one principal use is in the manufacture of electric lamps, although it is used to some extent in several articles required to be made of metal of

Fig. 3.
CONCENTRATING REFLECTOR.

Fig. 4.
DISTRIBUTING REFLECTOR.

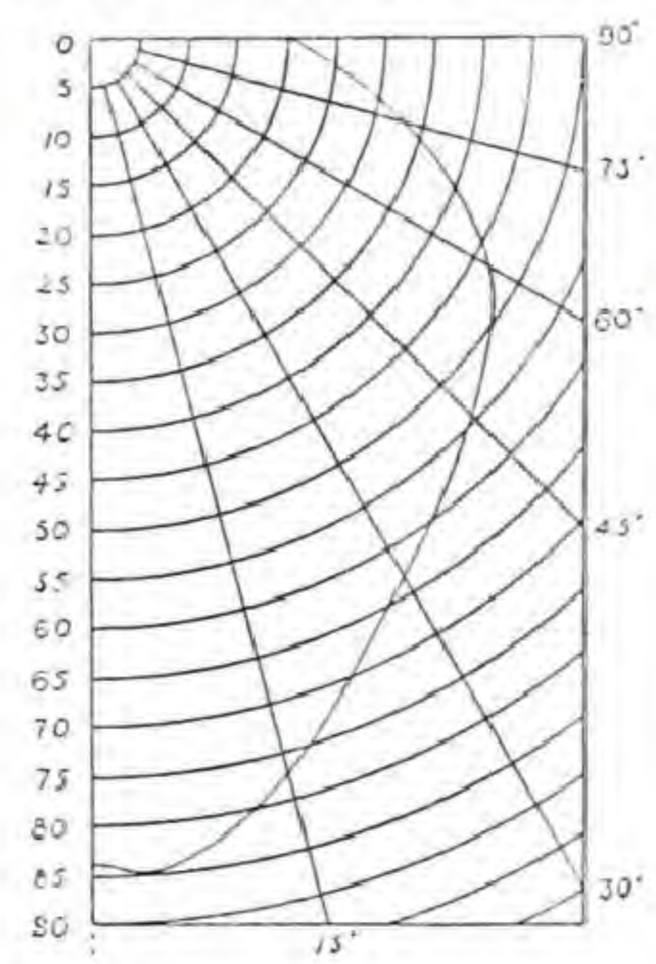


Fig. 3 A.

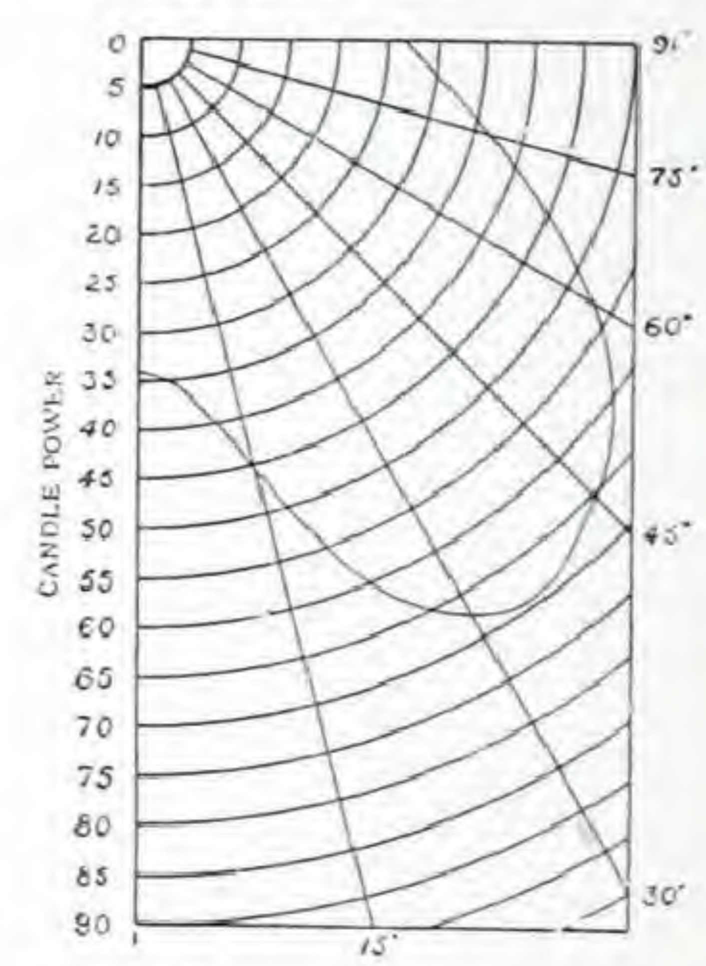


Fig. 4 A.

TUNGSTEN ELECTRIC LAMPS AND CANDLE POWER CURVES.

extreme hardness, such as pens. Tantalum can be made as hard as the diamond, and were it a cheap metal it would be ideal for armor plates, dies, drills, etc. While its price is relatively high, it is said that one pound will make the filaments for about 20,000 incandescent lamps.

When cold, the metal is extraordinarily inert, being attacked by practically only one acid (hydrofluoric), and no alkali. It combines very easily with carbon. The specific gravity when melted and drawn is 16.8, and in powder with oxygen and hydrogen present it has a specific gravity of 14. It can be rolled and drawn into a fine wire, and has about 15 per cent. more tensile strength than good steel. From this wire, electric filaments are made. Its high melting point places Tantalum in the class of high efficiency lamps, although it is much less efficient than the newer lamp, Tungsten.

GENERAL DESCRIPTION OF TANTALUM LAMP. Fig. 2 shows a Tantalum lamp, which is very similar in appearance to the Tungsten. It, too, gives a good, white light, which commends it for general use, and it has recently been perfected to operate well on either direct or alternating current (6). Next to the Tungsten lamp, the

Fig. 5.
CONCENTRATING REFLECTOR.

Fig. 6.
DISTRIBUTING REFLECTOR.

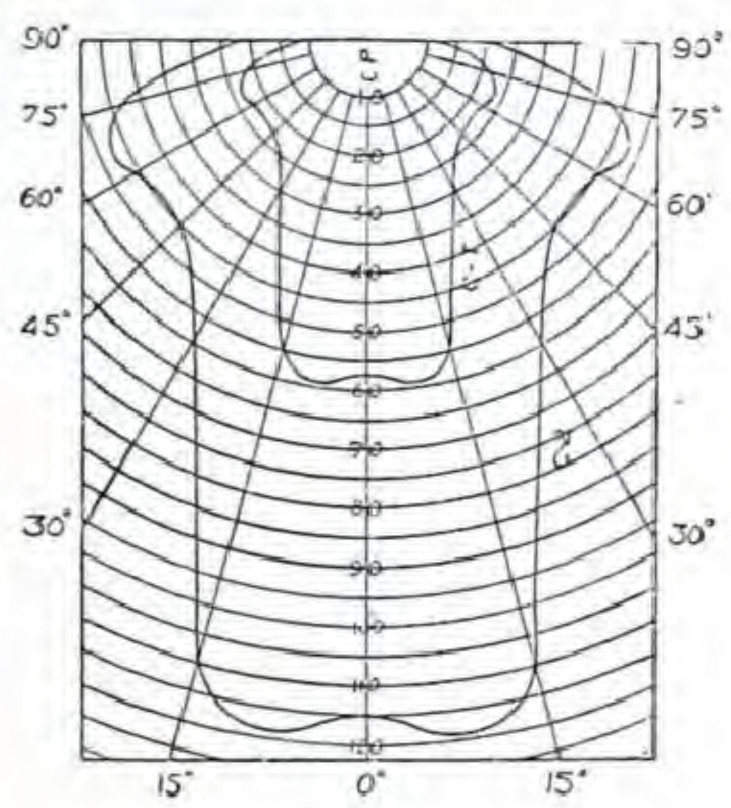


Fig. 5 A.

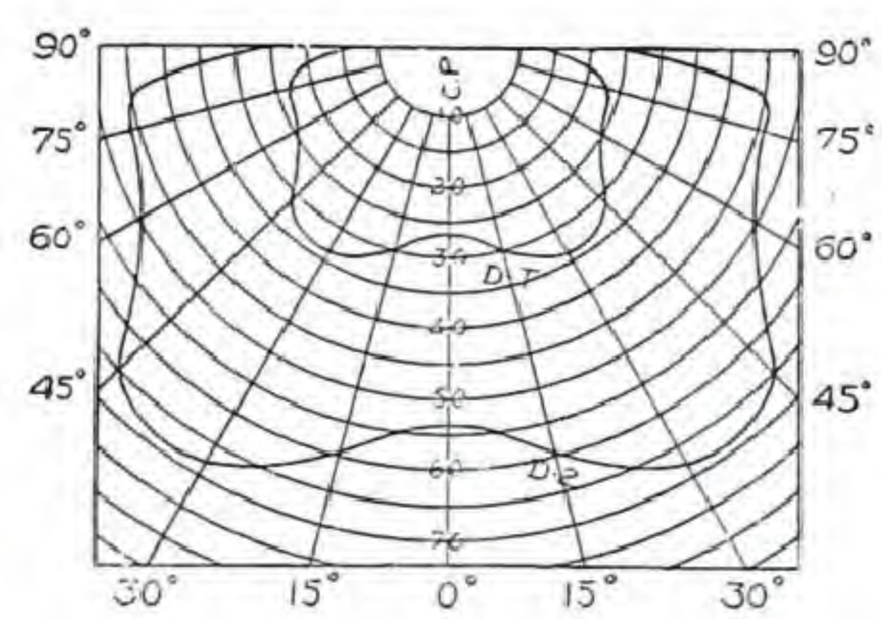


Fig. 6 A.

TANTALUM ELECTRIC LAMPS AND CANDLE POWER CURVES.

Tantalum is the most efficient commercial electric incandescent lamp in use in this country.

The development of the lamp was due to Drs. Van Bolton and Feuerlein, of the Berlin Siemens-Halske Company.

CANDLE-POWER OF TANTALUM LAMP. Tantalum lamps can be obtained in Regular style, 40, 50, or 80 watts, and the Meridian style, 40 and 80 watts, the rated efficiency being 2 watts per candle-power. This is the maximum horizontal intensity, which falls very low at the tip, being but 5 tip c. p. for the 40-watt lamp and 9.75 tip c. p. for the 80-watt lamp (6). The use of efficient reflecting glassware is necessary for changing the distribution from horizontal to vertical, and it will be noticed that all candle-power distribution curves as published always show the lamp with a special reflector.

The average life of the lamp is 600 hours for the 40-watt lamp and 900 hours for the 80-watt lamp (6). Tantalum lamps are generally sent out to give less

light than their rating, for in about the first five hours' burning the candle-power increases 15 per cent. to 25 per cent., owing to the filament changing to the form of a series of semi-globular masses (5). There is afterward a diminution of light, but throughout their rated life they will average 90 per cent. of their nominal candle-power (6).

When the filament breaks it will often weld together if the ends happen to come in contact, or are shaken in contact, resulting in an increased candle-power and shorter life, due to its shortening and decreased resistance.

In Figs. 5—5a and 6—6a are shown Tantalum lamps equipped with two styles of Holophane reflectors. From the distribution curves the particular use of each reflector is obtained. Note in Fig. 5 that the 80-watt, 40-horizontal candle-power lamp has had its vertical candle-power increased from 9.75 to 110 candle-power. This, of course, has been at the expense of light in other directions, as there has actually been a loss in the mean spherical candle-power, due to the interposition of the reflector. The downward light is the valuable, useful light.

INVERTED GAS LAMPS.

GENERAL DESCRIPTION. The Inverted type of incandescent gas lamp shown in Fig. 7 marks the latest step in the advancement of gas lighting.

In general, the burner and mantle are in substance the same as the familiar upright mantle burners, adapted, however, to burn in the inverted position. The light from such a combination is wholly unobstructed in the lower hemisphere, and 67 per cent. of its total light is thrown downward without the necessity of reflectors. The upright burners with reflectors distribute 55 per cent. of their total light above the horizontal (7). The great

Fig. 7.
REFLEX INVERTED GAS LAMP.

advantage of this one point can be readily appreciated. If reflectors are used they are simply supplemental, as two-thirds of the light is thrown down without them, thereby saving the loss necessary where it is required to reflect all the light. The design of the inverted burner is attractive in appearance, lending itself to all kinds of decorative effects, and it is adjustable to almost every conceivable scheme of illumination.

The lighting element, the mantle, is much shorter than the upright mantle, and its downward end is hemispherical. These features produce more perfect combustion at the mantle surface, increasing its temperature and efficiency. The size and character of the mantle and its mounting give it greater strength and longer life than mantles of the upright type.

The quality of light is exceptionally pleasing to the eye. It is a near approach to daylight, and has been pronounced by many color specialists ideal for truly judging delicate shades and matching colors.

The extremely high temperature at which the mantle is operated, its greater efficiency, greater downward light, and small radiating surface are factors which materially reduce the heat units per candle-power over other forms of incandescent gas lights.

By using a small amount of the total light and distributing it above the horizontal for producing color and decorative effects, there is still left a large volume of natural downward light, unaffected for its real work, i. e., illumination. Reflectors and globes of all styles and for all requirements can be had which will produce a soft, diffused, pleasing and mellow light, or an intense searchlight effect, as the case requires.

THE INVERTED GAS ARC LAMP. The many points of superiority in the single Inverted gas light have indicated to manufacturers the desirability of making a larger unit of the cluster lamp type. In a short time Inverted Gas Arc lamps of medium and large candle-power will be on the market, embodying all the excellent features of the single Inverted lamps.

CANDLE-POWER OF INVERTED LAMPS. There is but one size of the Inverted lamp as illustrated, i. e., 75 candle-power (8), which is the maximum light obtained in one direction, the vertical. This is without the aid of reflectors, and shows well the peculiar advantage which the lamp has in its **natural** downward distribution. The distribution of the natural light between horizontal and vertical is exceptionally good, being 50 candle-power on the horizontal.

This light consumes three feet of gas or less, giving an efficiency of 25 candles per cubic foot. The life of Reflex mantles is not guaranteed, as they may be easily broken by mechanical injury, but from experience in maintaining these lights it is known that 600 hours' burning is a fair average, in which time the candle-power will not drop over 20 per cent. Unlike electric filaments, mantles never burn out. Mechanical breakage usually determines

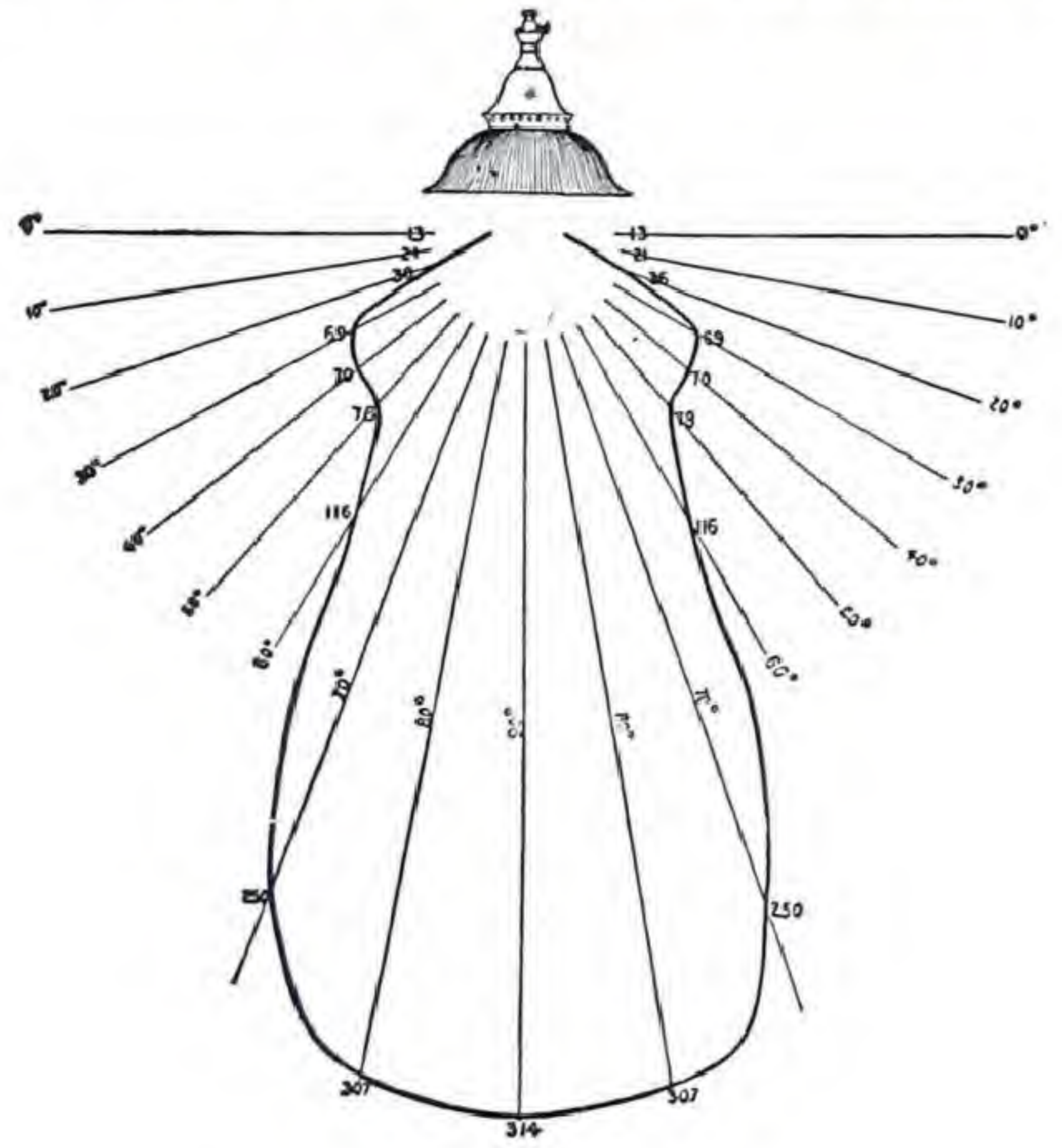


Fig. 8.
CONCENTRATING REFLECTOR.

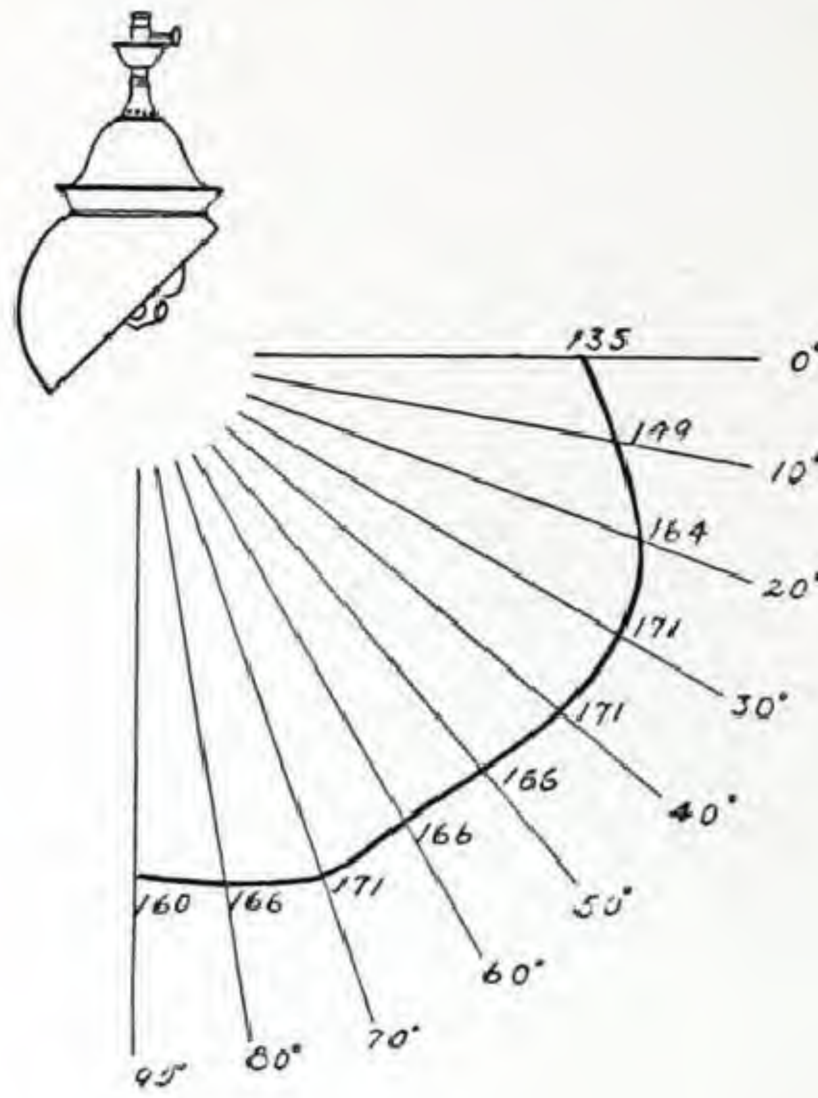


Fig. 9.
ANGLE REFLECTOR.

REFLEX INVERTED GAS LAMP. CANDLE POWER CURVES.

their life, although it is generally economical to renew unbroken mantles after about 800 hours' burning. After this time the decreased efficiency makes it more expensive to operate the old than to buy a new mantle, when it is considered that illumination, and not gas, is the product paid for.

In Fig. 8 a Reflex light is illustrated with a concentrating Holophane reflector, No. 6333. The large volume of light possible to be obtained from a single unit of this kind is plainly shown by the curve—314 c. p. in the vertical direction. In window lighting, by spacing the lights near together, a remarkable volume of white light is thrown on the goods, showing them off in their true qualities and colors. For this class of work this combination is ideal, and, by the aid of the numerous devices recently perfected, it is possible to light the windows by the turn of one key placed at any convenient location.

In Fig. 9 is shown a special form of angle reflector, designed to throw most of the light forward and downward, producing an almost uniform candle-power curve of evenly distributed light. It is particularly adapted for certain forms of window lighting, for bowling-alleys, show-windows, etc., or any place where the eye should be shielded and the light thrown in one general direction.

Fig. 10 shows the Reflex light with No. 503 opal shade. This gives a general distribution of light with the maximum still in the vertical direction. Fig. 13 shows the Reflex light with a No. 442 French roughed globe. While this subdues the light, making it soft and pleasant, the amount cut off by the globe is very small, and the distribution remains exceptionally good for general lighting, the larger percentage always being in the lower hemisphere.

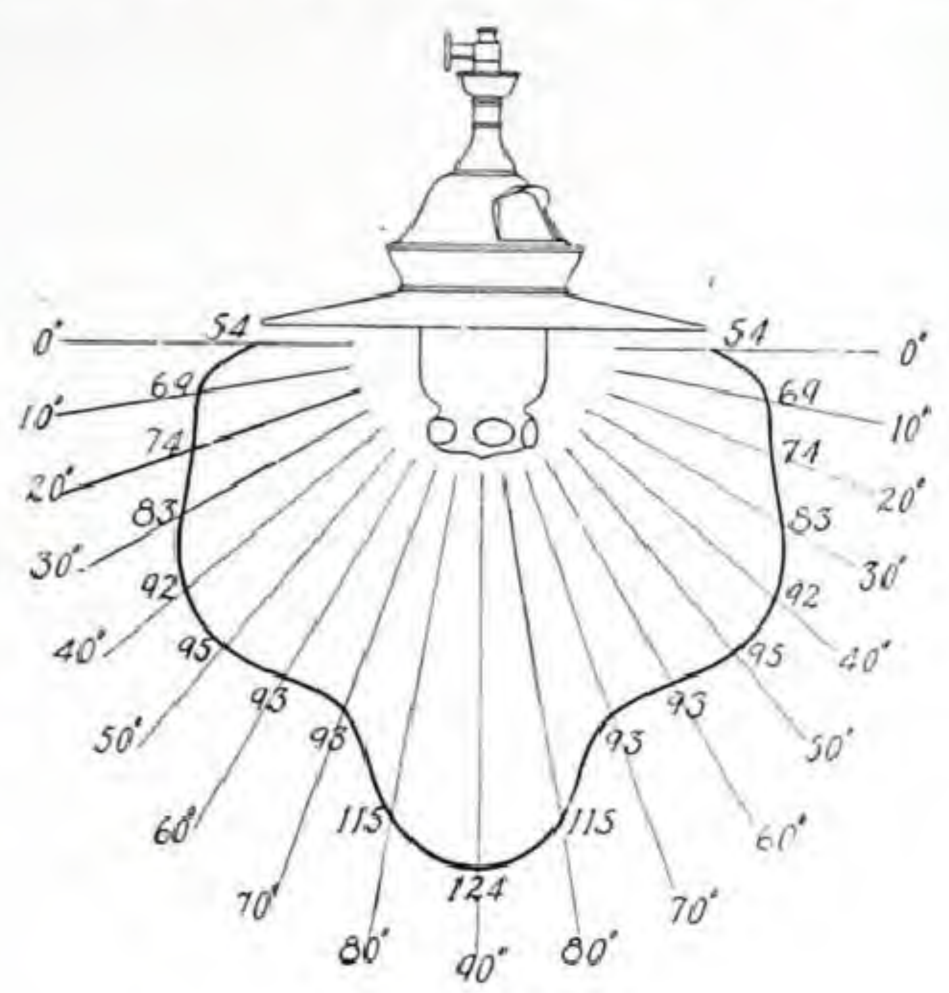


Fig. 10.
FLAT SHADE.

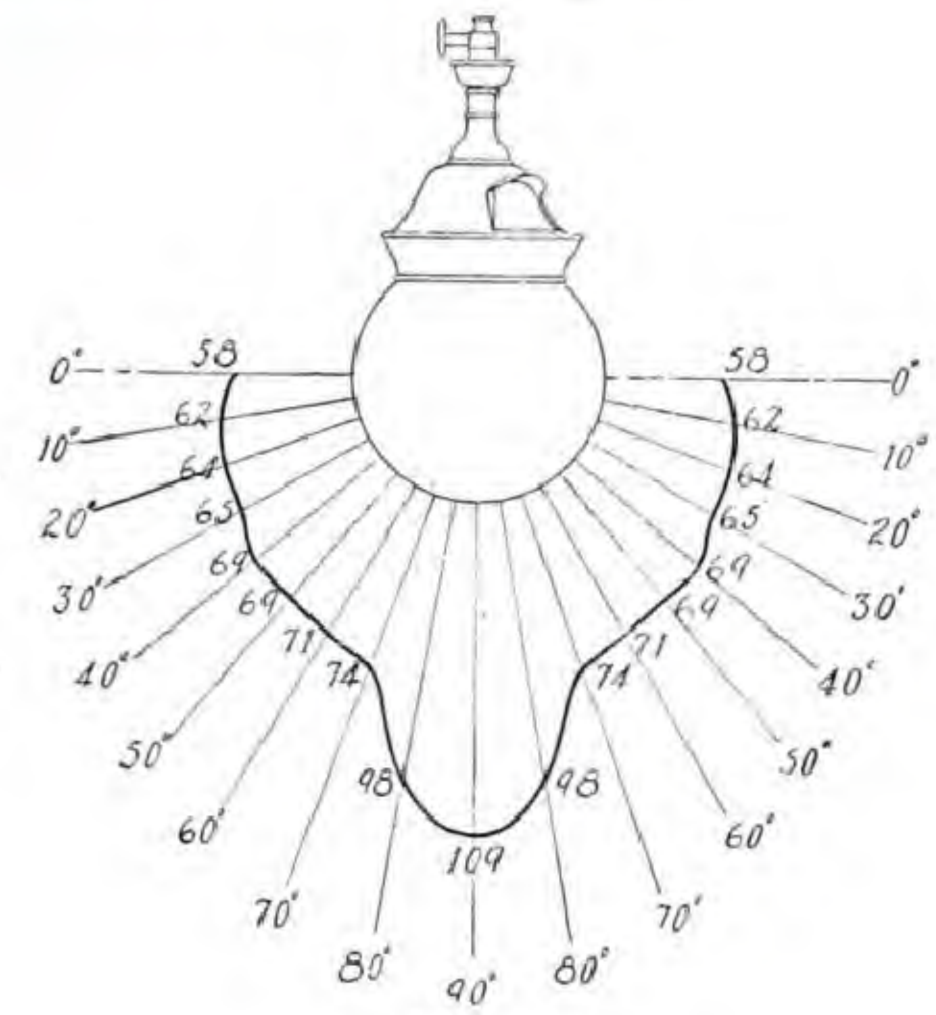


Fig. 11.
BALL GLOBE.

REFLEX INVERTED GAS LAMPS. CANDLE POWER CURVES.

GAS ARC LAMPS.

GENERAL DESCRIPTION. In Fig. 12 is shown a Gas Arc lamp, needing little introduction. This lamp has been on the market four years. Although it is a lamp giving a much larger unit of light than the former types considered, it is often compared with them in figuring the cost of illumination.

The lamp, in brief, consists of four mantles mounted on four burners, enclosed in one large globe, controlled by one single cock, operated conveniently by chains, and above the globe is a draught inducer. The metal parts are finished in durable nickel. A pilot light is maintained in the cluster of mantles, and this, by its flash, lights the separate burners when the chain is pulled. It is simple, economical, and satisfactory to all using it. It appeals to gas companies, as it does to those who appreciate a well-made mechanical device, easily assembled, and easily cleaned and repaired in situ. These are features of great importance to those caring for the lights.

Gas Arc lamps are most suitable for the lighting of large areas, and, supplemented by smaller units for special lighting, make an ideal system. The quality of light is absolutely steady,—no flickering, no shadows,—and is very

Fig. 12.
WELSBACH GAS ARC LAMP.

near daylight in color, being neither too blue nor too red. It never goes out leaving the place in darkness; thunderstorms do not affect it. Beauty of design and perfection of finish make the Gas Arc a decorative feature wherever used. It can be installed with ease on any outlet, and can be used to good advantage in lighting windows with special reflectors.

CANDLE-POWER AND CHARACTERISTICS. The maximum candle-power in the horizontal direction of a four-burner Gas Arc lamp with clear globe is 392, and the lamp consumes 18.8 cubic feet per hour (8). The nominal efficiency, therefore, is about 20 candles per foot.

When it is considered that this candle-power represents but three mantles (one mantle being behind the center feed pipe), the above performance is quite remarkable. The horizontal candle-power varies somewhat, according to whether there are two or three mantles visible.

Our experience in maintaining a great many lamps has proved that the average life of arc mantles is 400 hours' burning.

From Figs. 13, 14, 15, and 16 the candle-power and distribution are shown from Gas Arc lamps equipped with various styles of glassware. For a soft, mellow light, the alabaster globe is used, and for a greater downward illumination the reflector is used. Glassware and appliances are on the market to fit every requirement.

TABLE OF LAMP DATA AND COMPARATIVE COSTS.

	Gas Arc.		Gas Inv.		Tantalum.		Tungsten.	
1. Rate per cu. ft. and per K. W. hr.	$1.00		$1.00		10c		10c	
2. Consumption per hr. in cu. ft. and watts	18.8	(11)	3.0	(12)	40.0	(6)	60.0	(3)
3. Rated C. P.	375	(11)	75	(11)	20	(6)	48	(3)
4. Rated efficiency (C. P. per ft. or watts per c. p.)	20		25		2		1¼	
5. Mean spherical C. P. of unit (Tant. 40 watt, Tungsten 60 watt)	228.7	(11)	54.0	(12)	15.8	(6)	36.6	(3)
6. Mean S. C. P. eff.	12.16		18.0		2.53		1.64	
7. Mean lower hemispherical C. P. of unit	244.0	(11)	70.6	(11)	16.4	(10)	39.36	(10)
8. Eff. mean L. H. C. P.	12.97		23.53		2.4		1.5	
9. Hrs. life of unit	400	(11)	600	(11)	600	(6)	800	(3)
10. First cost of unit	$10.00	(16)	$1.50	(16)	60c	(6)	$1.75	(3)
11. Price each of renewals	15c	(16)	25c	(16)	30c	(10)	$1.10	(9)
12. Cost of consumption for 1,000 hrs.	$18.80		$3.00		$4.00		$6.00	
13. Cost for cons. and renewals per 1,000 hrs.	$20.30		$3.42		$4.50		$7.38	
14. Comparative cost of cons. and renewals per 1,000 hrs. reduced to 100 mean S. C. P.	$8.87		$6.33		$28.48		$20.16	
15. Comp. cost cons. and renewals per 1,000 hrs. reduced to 100 mean L. H. C. P.	$8.32		$4.84		$27.44		$18.75	
16. Weekly inspection and maintenance yearly charge	$7.20	(16)	$2.40	(16)	Elec. Co. have none.		Elec. Co. have none.	

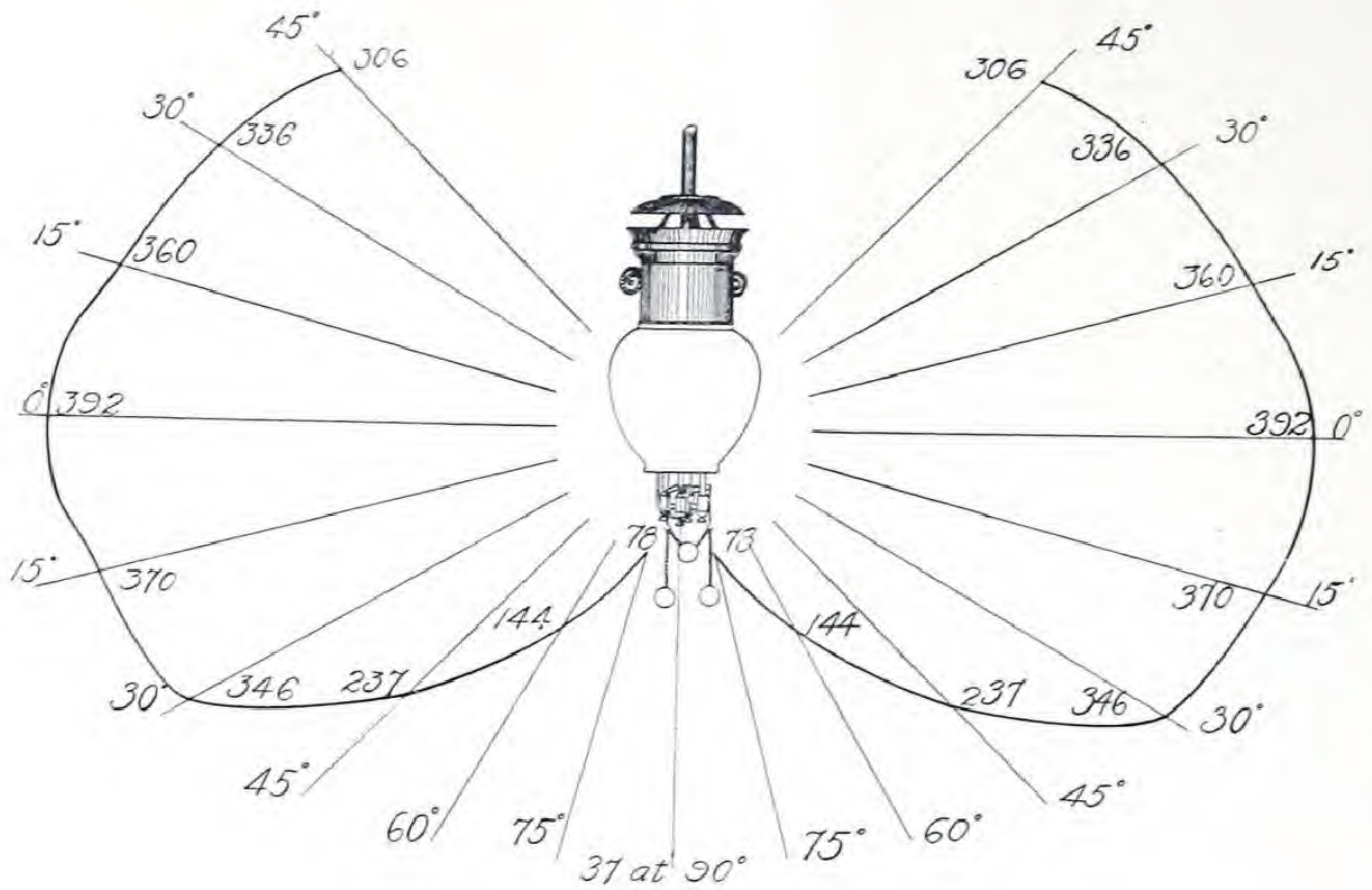


Fig. 13.
PEAR SHAPED CLEAR GLOBE.

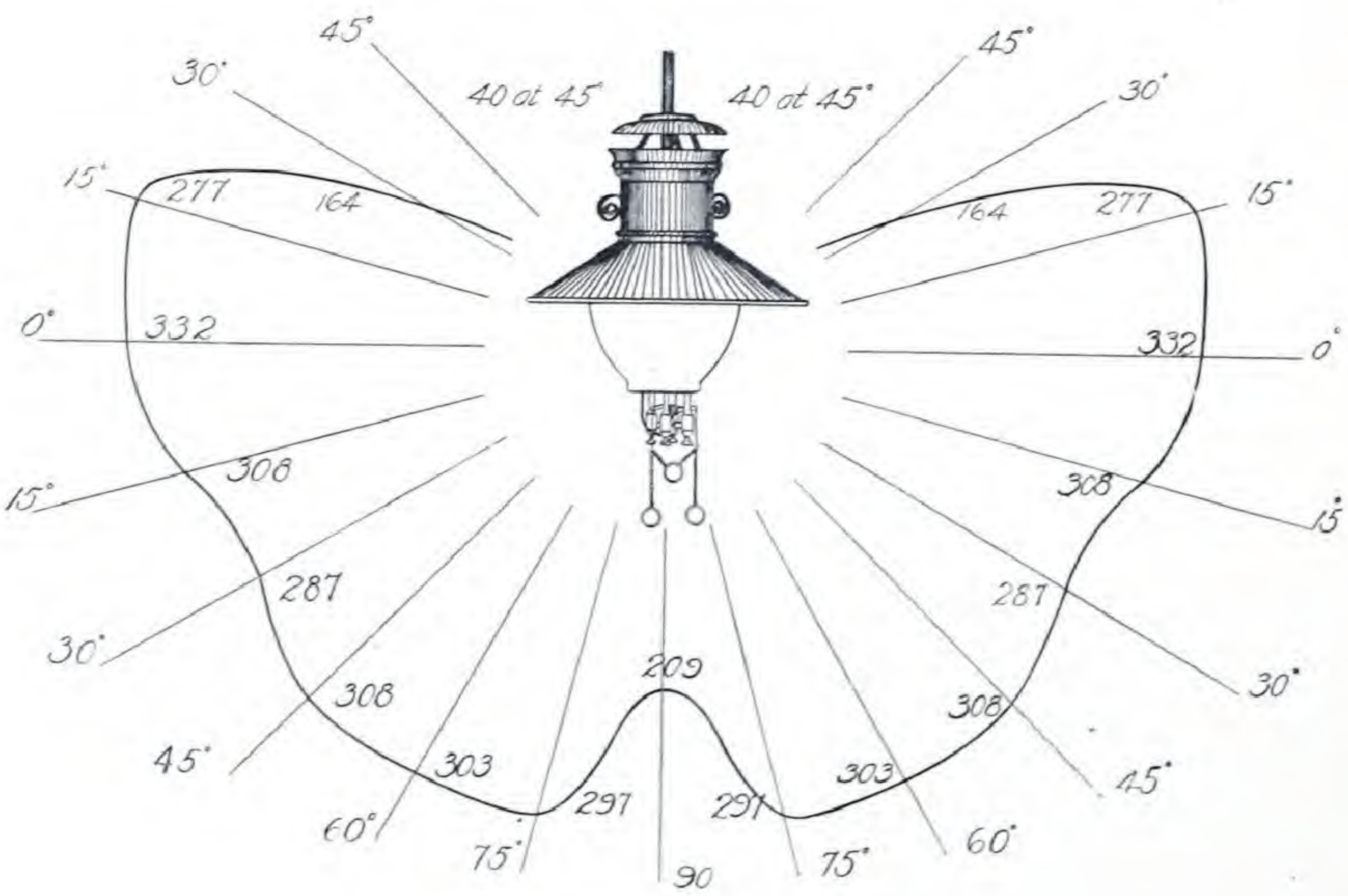


Fig. 14.
CONCENTRATING REFLECTOR.

GAS ARC LAMP. CANDLE POWER CURVES.

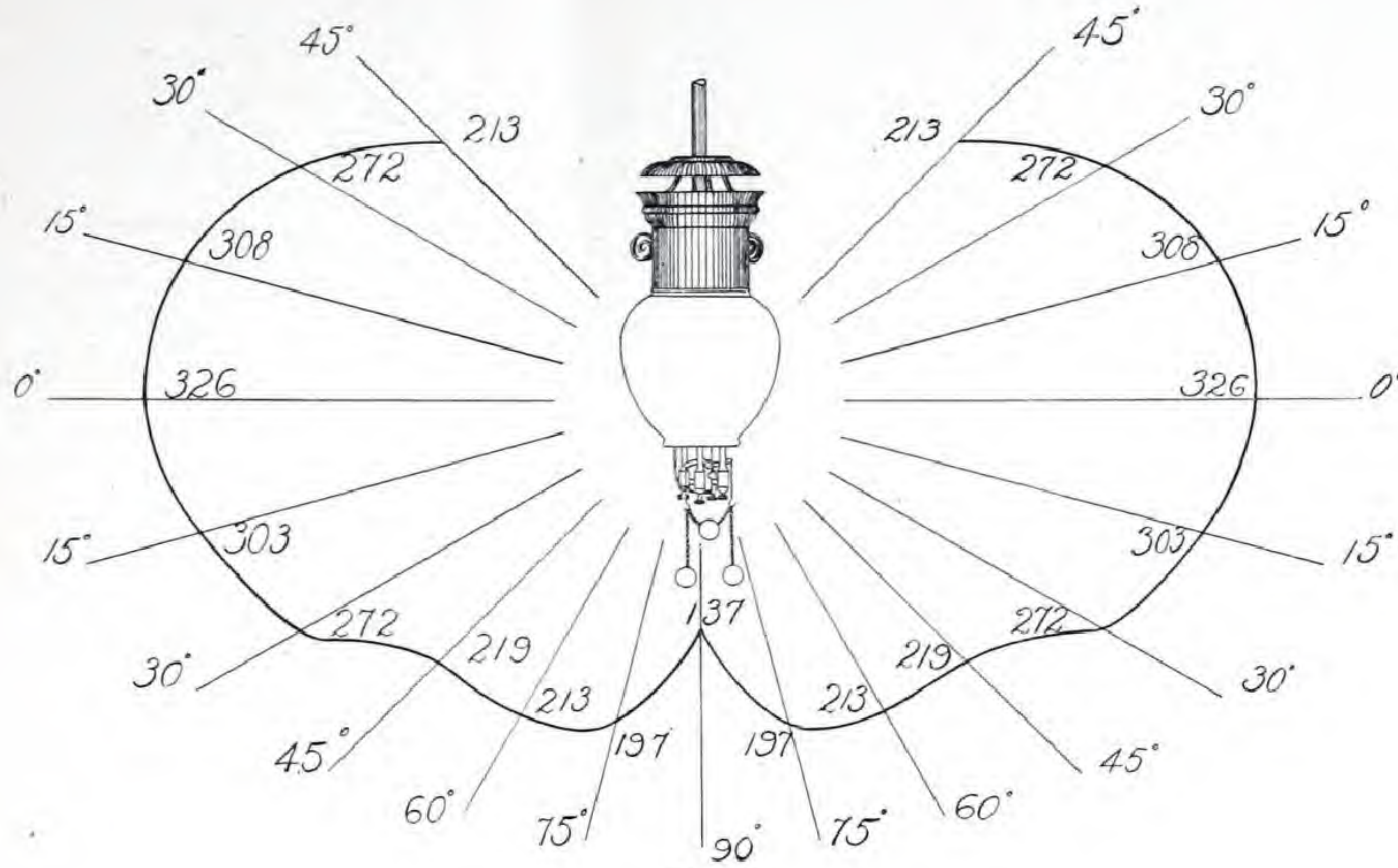


Fig. 15.
PEAR SHAPED ALABASTER GLOBE.

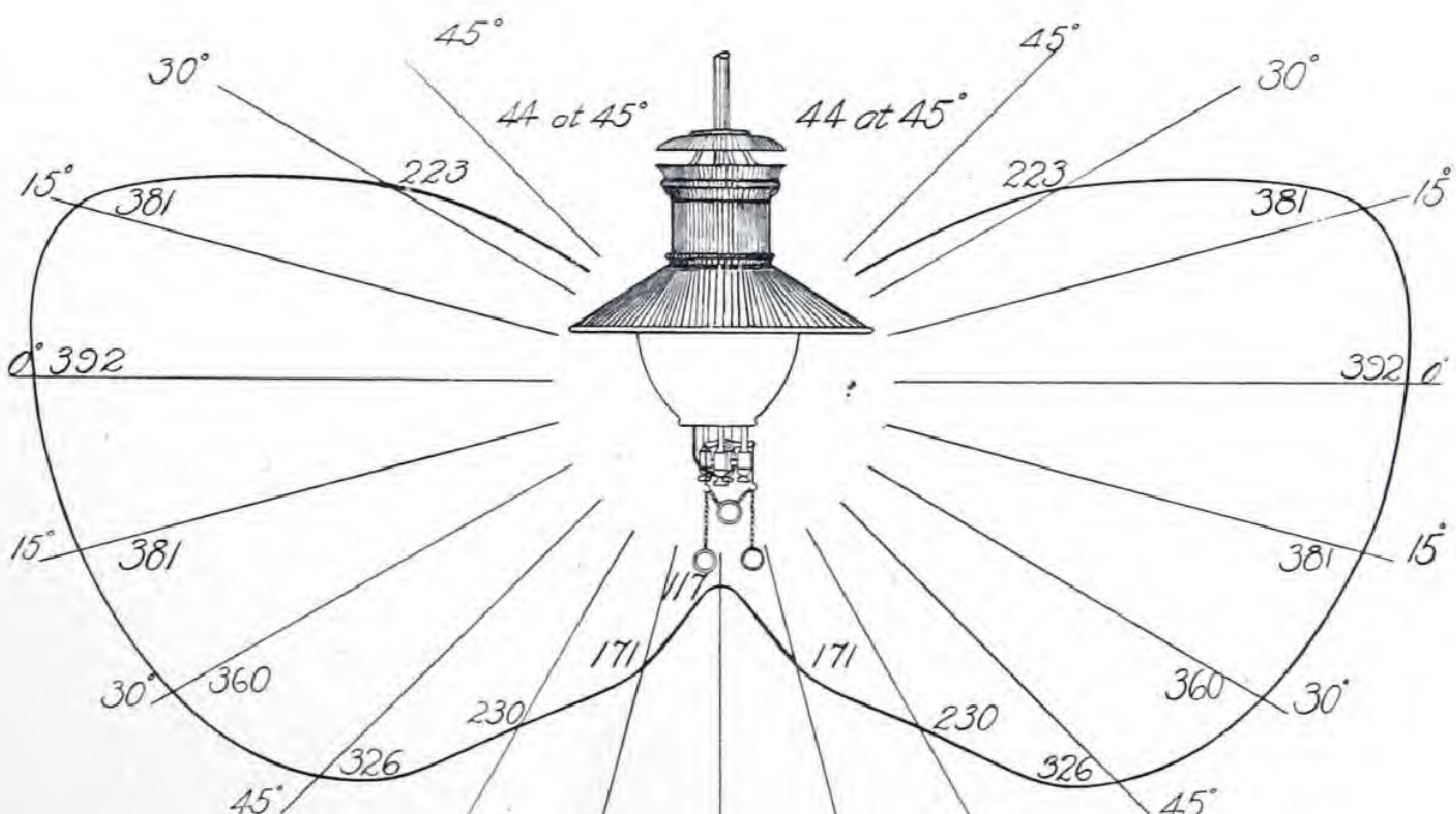


Fig. 16.
DISTRIBUTING REFLECTOR.

GAS ARC LAMP, CANDLE POWER CURVES.

17. Cost for cons. and I. & M. for 1,000 hrs.	$26.00	$5.40	$4.50	$7.38
18. Comp. cost cons. and I. & M. per 1,000 hrs. reduced to 100 mean S. C. P.	$11.37	$10.00	$28.48	$20.16
19. Comp. cost cons. and I & M. per 1,000 hrs. reduced to 100 mean L. . C. P.	$10.65	$7.64	$27.44	$18.75
20. Comp. cost including first cost cons. I. & M. per 1,000 hrs. reduced to mean S. C. P.	$15.74	$12.77	$32.28	$24.94
21. Comp. cost inc. first cost cons. I. & M. per 1,000 hrs. reduced to 100 mean L. H. C. P.	$14.75	$9.77	$31.10	$23.19

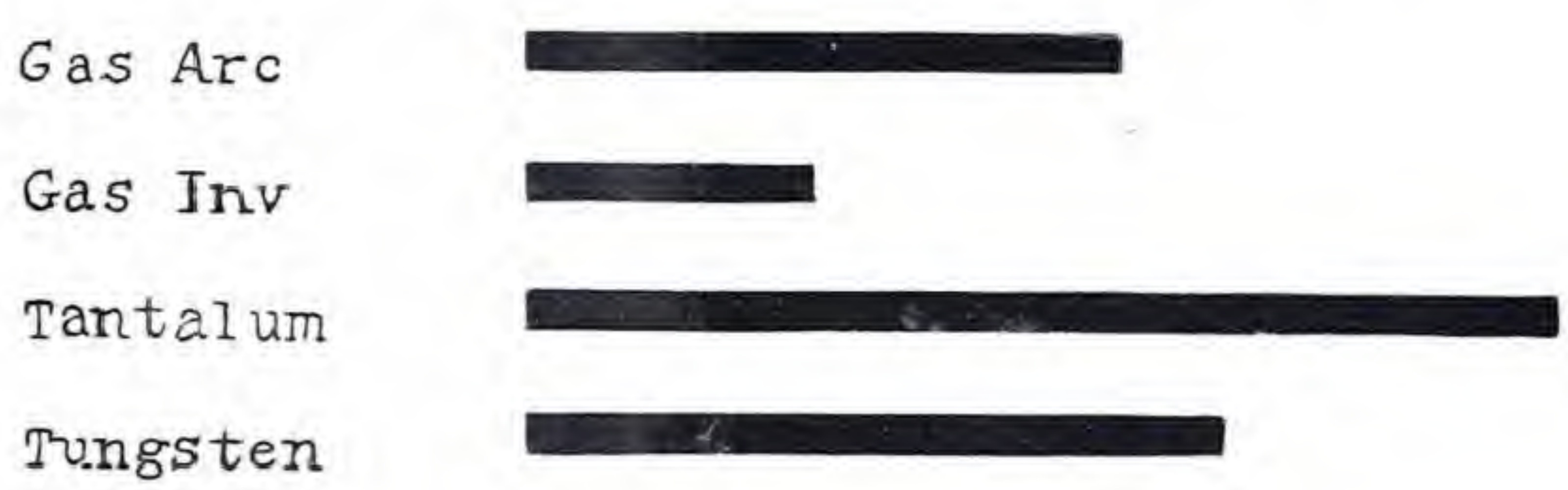
COST ANALYSIS. The proper way of rating illuminants is a question not finally settled. It will be noted that in all commercial figures lamps are rated on the maximum candle-power in some given direction. The standard for scientific rating is the mean spherical candle-power, i. e., the total flux of light measured all over the surface of a sphere of given diameter with the light source in its center. This is not regarded as the correct principle for commercial rating, as it does not give an idea of the value of a lamp for practical illumination, and furthermore, such a rating is wrong, generally speaking, because a light source may be of high spherical candle-power, yet when equipped with accessories to direct the light where needed it is much lower in efficiency than a lamp which may give, by virtue of its design and construction, a better distribution. **For this reason the value of a light should be determined and compared on the basis of mean lower hemispherical candle-power** (14) (15).

The comparative costs have been worked out on both bases, the spherical and lower hemispherical, but have not been compared as to manufacturers' rated candle-power, as these are entirely misleading.

Referring to the preceding table, the gas rate at $1.00 and electric rate at 10 cents are believed to be as near an average as could be used for our analysis, although they vary in almost every city. The consumption for 1,000 hours is taken as the average time of burning lights for one year—practically three hours daily for 313 days. From these figures and others shown in the table,

Graphical Representation of Costs for Equal Mean Lower Hemispherical Candle Power Inc. Consumption and Renewals

Graphical Representation of Costs for Equal Mean Lower Hemispherical C P. Inc Cons & I & M



Graphical Representation of Costs for Equal Mean Lower Hemispherical C. P., Inc. 1st Cost, Consumption & I. & M.

taken from standard authorities (footnotes), results have been obtained showing actual comparative costs of the four lamps under discussion. To obtain exact figures with any particular gas and electric rates, simply substitute them in place of the $1.00 and 10 cent rates.

Example: To figure for the Gas Arc in detail, proceed as follows: To obtain the rated efficiency, divide the rated candle-power (375) by the consumption (18.8), which equals in round numbers 20. Dividing the mean spherical C. P. (228.7) by the consumption (18.8) is obtained the mean S. C. P.

efficiency (12.16), and in the same way the Mean Lower Hemispherical C. P. efficiency (12.97) is obtained by dividing the Mean L. H. C. P. (244.0) by the consumption (18.8).

The cost for consumption of gas for 1,000 hours ($18.80) is obtained by multiplying the consumption per hour (18.8 feet) by 1,000 hours and multiplying this by the rate per 1,000 cubic feet ($1.00) reduced to the rate per foot ($.001). If one mantle lasts 400 hours, each of the four burners uses two and one-half mantles per year, or four burners use ten mantles per year, at 15 cents each, or $1.50 for the cost of renewals. Adding the cost for renewals ($1.50) to the cost for gas ($18.80) gives the cost for gas consumption and renewals ($20.30) for 1,000 hours. The cost for 228.7 M. S. C. P. for 1,000 hours is $20.30, and by dividing $20.30 by 228.7, and multiplying by 100, is obtained the cost for 100 M. S. C. P. for 1,000 hours, or $8.87. The cost for 100 Mean Lower Hemispherical C. P. for 1,000 hours is obtained in the same way by dividing $20.30 by 224.0 and multiplying by 100 (244.0 is the M. L. H. C. P.), which gives $8.32. By adding the cost for gas for 1,000 hours ($18.80) to the inspection and maintenance cost ($7.20), a total cost of $26.00 is obtained for the lamps burning 1,000 hours. Dividing $26.00 by 228.7 (M. S. C. P.) and 244.0 (M. L. H. C. P.), respectively, and multiplying each by 100, is obtained $11.37 for M. S. C. P. and $10.65 for M. L. H. C. P. as the cost for gas consumption and inspection and maintenance for 1,000 hours reduced to 100 M. S. C. P. and 100 M. L. H. C. P., respectively.

Dividing the lamp cost of $10.00 by 228.7 M. S. C. P. and 244.0 M. L. H. C. P., respectively, and multiplying each by 100, are obtained $4.37 and $4.10 for the lamp cost of 100 M. S. C. P. and 100 M. L. H. C. P., respectively. Adding $4.37 to $11.37 gives $15.74 as the total cost for 100 M. S. C. P. for 1,000 hours, including first cost, consumption, and inspection and maintenance. Adding $4.10 to $10.65 gives $14.75 as the total cost for 100 M. L. H. C. P. for 1,000 hours, including first cost, gas consumption, and inspection and maintenance.

It is very noticeable, by referring to columns 4, 6, and 8, how the rated or nominal efficiency is reduced when the actual total light or the actual total downward light is taken for our standard. Comparing line 5 with line 3, notice that the M. S. C. P. is lower in all cases than the rated C. P.

Line 12 shows comparative costs of consumption of the units, regardless of their candle-power, and line 13 shows comparative costs of the different units, including their renewals.

For a consumer caring for his own lights, lines 14 and 15 show actual comparative costs reducing the lights to the same candle-power, and including the renewals. Line 15 shows the most accurate comparison, in that the downward light is the useful light. Note here the very low cost of lighting with the Inverted Gas lamp, which is about one-fourth the cost with the best Electric. (Tungsten.)

Some companies furnish a system of inspection and maintenance on gas lamps. This includes, besides weekly cleanings, free renewals of glassware and mantles. Line 16 shows these rates on the lamps considered. A customer on this service can figure his gas cost and add it to his inspection and maintenance cost and obtain his total cost, there being but the two costs to figure in determining his total lighting bill. The electric companies have a similar service in their lamp renewals. The old carbon filament lamps were renewed free of charge, but for the two lamps in question a nominal charge is made for renewals, as shown in line 11. Comparing the cost for consumption and inspection and maintenance (for the gas) and consumption and renewals (for the electric) and reducing to an equal candle-power basis, lines 18 and 19 show the figures. The best electric (Tungsten) costs about two and one-half times as much as the gas Inverted. If, for further comparison, the first costs are considered, the figures are shown in lines 20 and 21. A consumer, in buying illumination, can get the same results with the Inverted Gas lamp as with the Tungsten Electric and save over 57 per cent. of the cost. This takes into consideration the purchase price of the lamps and their entire upkeep, with weekly cleaning and all free renewals when required.

The cost of wiring for electric and piping for gas is about the same for moderate-sized installations. If the electric installation includes wall switches the cost for electric is materially higher than for gas.

The point may be raised in the minds of some that the figures on the various lights compared should have been taken with their standard glassware. In answer to this, it was considered that whatever change might result by using any style reflector (changing the distribution of the light) could be produced as well on one or all, but not in reality putting them on the same basis. The peculiar construction of one lamp or its inherent features might require a certain kind of reflector more than another, in which case it would be manifestly unequal to compare them with the reflectors, as the loss by each different reflector would have to be deducted. The comparison of bare lamps is, therefore, considered to be more nearly accurate.

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